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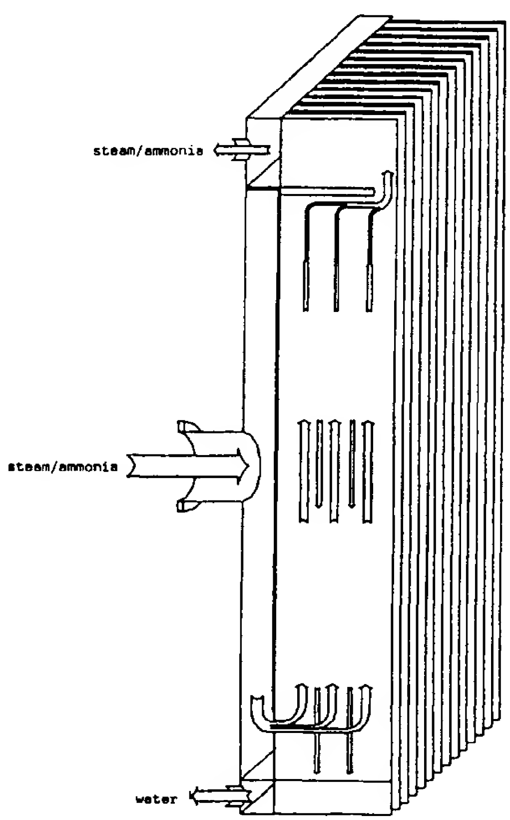
(54) Title: PROCESS AND APPARATUS FOR CLEANING OF WASTE WATER

(57) Abstract

A process for cleaning of waste water and a corresponding apparatus for the embodiment hereof is described. By the process a column step is combined with a heat exchanging step, where the vapours from the waste water are led to the column, where the compounds in the waste water, which comprise more and less mobile compounds in relation to the mobility of the water, including inter alia weak acids and weak bases, will react and can be removed. By cleaning of manure an essential reaction between acetic acid and ammonia will occur. Additional compounds, including the more mobile compounds, inter alia ammonia, are conducted as steam via a compression step further on to the heat exchanger, where they condense and flow countercurrently to its own condensate. From the heat exchanger the more mobile content compounds can hereafter as steam be removed for possible further heat exchanging. The well cleaned waste water can at the bottom be drained off as condensate. By heat exchanging of manure an essential part of the more mobile compounds will consist of ammonia, which drained off at the top of the heat exchanger.



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Process and apparatus for cleaning of waste water.

The present invention relates to a process for improving plants for waste water cleaning, in which evaporation by means of steam compression as a cleaning method is a part.

Waste water cleaning plants, which use evaporation by means of steam compression, are typically minor plants for cleaning of a special kind of waste water such as e.g. heavy metal containing waste water, used cooling lubricants, water-based degrease liquids and waste water from various washing processes. The cleaned water has hitherto typically been reused or drained off for canalization. Types of waste water containing big amounts of compounds, which are mobile at the temperature and the pH at which the evaporation is taking place, are normally not suited for a cleaning-up process in a waste water cleaning plant, which uses evaporation by means of steam compression, because the cleaned water as a rule will be too unclean for re-use, and furthermore a draining off for canalization will be very problematic, because of a too big remaining content of mobile compound.

The process described in this invention makes waste water cleaning plants with evaporation by means of steam compression especially suited for cleaning of biological waste water containing mobile compounds in form of weak acids and weak bases.

As an example of a such kind of waste water, which often contains big amounts of mobile compounds, is waste water, which is produced in connection with one or more biological processes, such as e.g. manure from pigs, manure from cattles, toilet water, waste water from production of medicin, washing water from slaughteries and cooling lubricants, including said kinds of waste water, which have putrefied. A big part of the mobile compounds, which normally evolve by biological decomposition processes will be present as weak acid/base couples.

The present invention relates to a process for cleaning of biological waste water, which contains more mobile compounds and less mobile compounds in relation to the

mobility of water, and which are present as weak acids and weak basis. The proces uses inter alia an evaporation of the waste water, where the waste water is heated in a boiler. The formed steam is cleaned by this approach for unwanted gaseous compounds, and it is transferred from this boiling step via a compression step to a heat exchanging step, where the water is condensed and drained off in cleaned form to the recipient, and where the bigger part of the more mobile compounds is concentrated and drained off together with the remaining fraction of steam.

It appears that the described new process is advantageous in relation to prior art inter alia by the fact that the steam from the boiler is being led to a column, where the steam is tranferred in counterflow with a fraction of the condensed water. By this method the less mobile compounds are removed in a liquid form. Furthermore a part of the more mobile compounds and the less mobile compounds becomes a part of the related aqueous acid/base reactions.

Thus it appears that the less mobile compounds and a remaining part of the more mobile compounds are present in the steam from the heating of the waste water. These compounds are as mentioned led further from the column via the compression step to the heat exchanging step, where a concentration is taking place and draining off of the bigger part of the more mobile compounds together with a remaining fraction of steam, and where eventually condensed and cleaned waste water is led out to the recipient.

The invention encompasses furthermore an apparatus for the embodiment of the process.

By evaporation of the biological waste water, which contains more mobile compounds and less mobile compounds relative to the mobility of the aqueous solvent it is desirable that the amount of the more mobile compounds is as little as possible, because a presence hereof will require an increased supply of heat for a sufficient evaporation. The reason for this is that these more mobile compounds consist of compounds which are not condensable by the magnitudes of pressure and temperature which are applied

by the evaporation of the basic liquid of the solution, which normally is water, and therefore they will be inhibitory for the evaporation of water, because they are present as an insulating layer within the heat exchanger. Because such a layer will act as an inhibitor for the heat transmission to the condensable compounds within the heat exchanger it will implicate an increase of the energy consumption.

By evaporation of liquid biological waste the more mobile dissolved compounds present will inter alia be carbon dioxide and ammonia and the less mobile dissolved compounds will inter alia be fatty acids, mineral acids and their salts. Included are said compounds in both neutral and charged form.

Apart from the described increase of the sufficient heat transmission as a consequence of a presence of the more mobile compounds during the evaporation another kind of disadvantages will be present at the evaporation of such liquid according to prior art and this involves inter alia the energy consumption in the subsequent compression step. A content of not condensable compounds, as for instance carbon dioxide, will firstly occupy space within that water steam which is withdrawn from the boiler to the heat exchanger, and this implies a loss of efficiency. Secondly, the presence of the more mobile compounds in the water steam from the column will cause to an increase of the energy consumption in the subsequent compression step.

Another main compound, which belongs to the group of the more compounds, is frequently as mentioned above ammonia, which it is likewise desirable to remove, before the vapours are led into the heat exchanger. An applicable method for this is to conduct the ammonia vapours through a scrubber, as it is described in patent DK 171611. This has proven to be efficient, but does, however, involve disadvantages, as supply of various chemicals are needed, which is in detail described in patent DK 171611. Such a further proces step is both laborious and costly.

As mentioned compounds are present in the said liquid, which compounds are less mobile than the liquid in which they are dissolved, and the present invention comprises furthermore a removal of these compounds. A method for this is described in

patent application DK 01288/96, according to which a concentration of the compounds firstly takes place in the boiler used for the above described evaporation. The heated liquid is being led to a column, from which the more mobile compounds in gaseous form are led to the primary side of a first heat exchanger, so that these more mobile compounds are condensed and led out from the primary side, and from the same column the less mobile compounds are led in liquid form to the secondary side of the above mentioned first heat exchanger, where they are heat exchanged with the condensed more mobile compounds. By this approach additional parts of the more mobile compounds in the secondary side of the heat exchanger are evaporated and led to said column, from which they, in gaseous form, are led to the primary side of said first heat exchanger, and the heated liquid is led following a total or partly separation of the more mobile compounds back to the boiler. By more cycles of the column and the heat exchanger additional parts of the more mobile compounds are evaporated and carried to the column, from which they are circulated to the primary side, where they are condensed.

The present method is remarkable by a decreased enery consumption in relation to known methods and a consumption of chemicals which is totally eliminated. The invention will as an example in the following be described in more detail based on cleaning of manure, the method, however, is not to be limited to this. Examples of other liquids, which can be cleaned by an approach according to the present invention are - apart from the above mentioned biological waste liquids in general, which as already known inter alia comprise manure - emulgated liquids, as e.g. cooling/oil lubricants oil emulsions, degreasing liquids, oil containing waste water, waste water from laundries, solvents and waste water from food production and its like.

Based upon an example of manure as the liquid to be cleaned, the unwanted compound will comprise CO_2, NH_3, NH_4^+, fatty acids, including CH_3COOH, and other organic liquids. The unwanted compounds can be present in neutral and/or charged form and/or as salts.

A method and an apparatus of the known type can as an example be formed according to the disclosure in patent DK 171611. Here manure is de-gassed and during subsequent passage through a scrubber the present ammonia and acetic acid are neutralized by addition of calculated amount of acid and base.

In order to disclose the present invention in more details the technological background for this will be the until now known technology with reference to patent application DK 0868/94, patent DK 171611, and patent application DK 01288/96. The disclosure will be based on the below described figures 1-6, to which reference is made to an outline of the explanations for the used designations, which is placed at the end of the description.

Fig. 1 shows a plant for waste water cleaning with known technology by means of the scrubber 52 (comprising scrubber 53 and scrubber 54),

Fig. 2 shows a diagramme of an embodiment of a scrubber with known technology,

Fig. 3 shows a diagramme of an embodiment of the technology in a plant, which uses the present invention with column and heat exchanger,

Fig. 4 shows especially that part of the plant with combination of a column and a heat exchanger in Fig. 3, which the present invention makes use of,

Fig. 5 shows in- and outlets from a column in an embodiment according to the present invention and the relevant chemical equilibriums, and

Fig. 6 shows a diagramme of an embodiment of a heat exchanger with its in- and outlets according to the present invention.

In the description the known technique will be described based upon Fig. 1 with reference to Fig. 2, which especially discloses the function of the scrubber. By explanation of the approach in the present invention focus will be upon Fig. 3 with Fig. 1 as refer-

ence. Figs. 4-6 serve especially the purpose of showing those processes which in combination replace and improve the until now known scrubbing, which is included in Fig. 1.

Fig. 1 shows a schematic illustration of an example of an embodiment for a plant according to known technology from Danish patent application DK 01288/96. The plant comprises a column 1, a first heat exchanger 2, a compressor 3, a bottom vessel 4 for the column 1, a circulation pump 5 receiving liquid from outlet 36, a motor valve 6, a contravalve 7, a gas/liquid separator 8, a level sensor 9 for control of liquid level in the bottom vessel 4 for column 1, a first section 10 of a second heat exchanger, a second section 11 of the second heat exchanger, a third heat exchanger 12, a first motor valve 13, and a second motor valve 14. The column 1 is provided with nozzles 15 for draining off of liquid biological waste in column 1.

The column 1 is provided with an inlet 16 for the liquid biological waste to the column 1. As a non-limiting example of liquid biological waste will as mentioned manure be applied in the following part of the description. The manure is led to the column 1 in order to be separated in column 1 into more mobile compounds and less mobile compounds. The more mobile compounds are led to a foam restrictor 17 in an upper part of the column 1. The less mobile compounds are led to the bottom vessel 4 in the bottom of column 1. When the liquid biological waste is manure the more mobile compounds will inter alia comprise carbon dioxide (CO_2) and ammonia (NH_3), and the less mobile compounds will inter alia comprise water (H_2O), fatty acids and mineral salts.

Before the manure is led to column 1 the manure is heated, because it is led through a secondary side of the first section 10 and a secondary side of the second section 11 of the second heat exchanger. The first section 10 of the second heat exchanger is provided with an inlet 18 for the manure. The inlet 18 is provided with a motor valve 14 for inlet of the manure to the first section 10. The first section 10 is provided with an outlet 19, which leads to an inlet 20 for the second section 11 of the second heat exchanger. The second section 11 is provided with an outlet 21, which leads to the inlet

16 to the column 1. The manure is supposed to achieve a rise of temperature to the boiling point of the manure, before the manure is led to the nozzles 15 in column 1.

Following the transference of the manure through the nozzles 15 in column 1 and as mentioned separated into more mobile compounds and less mobile compounds the more mobile compounds are led from an outlet 22 from the foam restrictor 17 to the compressor 3, where the more mobile compounds are compressed. After the more mobile compounds are compressed the more mobile compounds are led to an inlet 23 of a primary side of the first heat exchanger 2. The more mobile compounds are led through the primary side of the first heat exchanger 2 to an outlet 24 from the primary side of the first heat exchanger 2. The more mobile compounds are thereafter led to an inlet 25 of a primary side of the second section 11 of the second heat exchanger. The more mobile compounds are led through the primary side of the second section 11 and to an outlet 26 of the second section 11 of a second heat exchanger.

After being led through the primary side of the first heat exchanger 2, respectively the second section 11 of th second heat exchanger the more mobile compounds are partly condensed and consist of a gas fraction and a liquid fraction. From the outlet 26 of the primary side of the second section of the second heat exchanger the gas fraction and the liquid fraction of the more mobile compounds are led to an inlet 27 to the gas/liquid separator 8.

The liquid fraction from an outlet 28 of the separator 8 is led to an inlet 29 of the liquid fraction and to nozzles 30 in column 1 as reflux. The gas fraction from the separator 8 with the more mobile compounds are from an outlet 31 led to an inlet 32 to a primary side of the third heat exchanger 12. In the third heat exchanger 12 a total condensing of the gas fraction is taking place. By condensing of the gas fraction the carbon dioxide (CO_2) diffuses into the liquid, where it together with water (H_2O) and ammonia (NH_3) form ammonia hydrogen carbonate (NH_4HCO_3). This ammonia hydrogen carbonate is led to an outlet 33 from the primary side of the third heat exchanger and it can be stored in a normal closed container (not shown) and can be drained off from here.

Those parts of the manure, which are led to the second heat exchanger, are as a start led to a secondary side of the third heat exchanger 12. The manure is led to an inlet 34 to the secondary side of the third heat exchanger 12 by means of the first motor valve 13 and through the secondary side of the third heat exchanger 12 to an outlet 35 from the secondary side. From the outlet 35 of the secondary side of the third heat exchanger 12 the manure is led through the inlet 20 of the secondary side of the second section 11 of the second heat exchanger.

The less mobile compounds are as mentioned led to the bottom vessel 4 of the column 1. From an outlet 36 from the bottom vessel 4 the less mobile compounds in liquid form are by means of a circulation pump 5 (receiving liquid from outlet 36) led to an inlet 37 for a secondary side of the first heat exchanger 2. The level sensor 9 in the bottom vessel 4 of the column 1 assures that the less mobile compounds are not led from the bottom vessel 4, before a sufficient amount of the less mobile compounds are present in the bottom vessel 4 of the column 4. The less mobile compounds are led through the secondary side of the first heat exchanger 2 for evaporation of possible additional more mobile compounds and back to the bottom vessel 4 of the column 1. Intermittently parts of the liquid containing the less mobile compounds are drained off during the circulation of the less mobile compounds from the bottom vessel 4 for the column 1 and through the secondary side of the first heat exchanger 2. The draining off from the secondary side of first heat exchanger 2 is taking place through outlet 38, through the contra valve 7 and the motor valve 6. The part of the liquid containing the less mobile compounds can be described as de-gassed, this is to say free of the more mobile compounds, and it can be led further on to a possible additional treatment such as an evaporation.

The more mobile compounds will by compression in the compressor 3 achieve a temperature which is higher than the temperature of the manure being led to the nozzles 15 of the column 1.

The less mobile compounds are led following passage of the motor valve 6 to a vessel 41 for the processing, which is connected with the scrubber 52 (comprising scrubber 53 and scrubber 54), and the functional correlation can be formed as described in patent application DK 0868/94, and reference is made to the following Fig. 2. According to the known technique the polluted liquid is heated in the vessel 41 for the processing linked to the scrubber 52 (comprising the scrubber 53 and the scrubber 54), whereafter a circulation pump 43 (connected with outlet from the processing vessel) is conducting the liquid to the top of the evaporator. At the bottom an outlet is provided, which can drain off the concentrated and polluted part of from the processing vessel 41, which is linked to the scrubber 52 (comprising the scrubber 53 and the scrubber 54. At the top of this a steam tapping 47 is provided, which is linked to a compressor 49, which furthermore via said scrubber 52 is connected with a downdraught evaporation heat exchanger 50, which is placed above the container for the processing vessel 41 (linked to the scrubber 52) within the evaporator. In the bottom of said heat exchanger 50 an outlet pipe 51 is placed for the clean condensate.

Fig. 2 shows a plant of known type from Danish patent application DK 0868/94 comprising inter alia an evaporator 39 and the scrubber 52. At the top of the evaporator a liquid distribution system 40 is provided, and at the bottom the vessel for the processing 41 is present (linked with the scrubber 52), which contains the concentrated processing liquid 42 (abbreviated C_c). The vessel for the processing 41 is connected with a circulation pump 43 and a circulation pipe 44, which pumps the heated and polluted processing liquid 42 to the distribution system 40 at the top of the evaporator. The vessel 41 for the processing, which as mentioned is connected to the scrubber 52, has an inlet pipe 45 for supply of polluted processing liquid 42 and an outlet pipe 46, which is used for emptying of the concentrated and polluting concentrate (abbreviated C_c) from the vessel 41 for the processing, which is connected to the scrubber 52 (comprising the scrubber 53 and the scrubber 54).

At the top of the processing vessel 41 a steam tapping 47 is provided, which via a pipeline 48 and a compressor 49 is connected with a downdraught evaporation heat exchanger 50, which is placed inside the evaporator 39. At the bottom of the heat ex-

changer 50 an outlet 51 is provided for clean condensate. The scrubber 52 (comprising the scrubber 53 and the scrubber 54) is placed in the steam pipe 48, in which also the compressor 49 is mounted. In the shown situation the scrubber 52 is placed upstream to the compressor 49. This is preferred, but it is also without difficulty possible to place the scrubber 52 downstream to the compressor 49.

It appears that the electrical managing of the plant is not shown in the drawing. However, such a managing system will be wellknown to a person skilled in the art and needs therefore no further explanation.

The polluted and concentrated process liquid 42 is transferred batchwise at the pipe 45 and drained off after an concentration has taken place via the outlet pipe 46. The clean condensate is drained off via the outlet pipe 51.

The scrubber 52 according to the known design comprises a first and a second scrubbing step 53, 54. The scrubber 53 contains an acid 55, and the scrubber 54 contains a base 56. Each of the scrubbers 53, 54 is provided with a pipe for acid 57 and a pipe for base 58. By this approach it is possible to exchange as a consequence of the measurements the liquid 55 and 56, so that the pH can be maintained constant during the evaporation.

The whole system is contained in a closed and insulated cabinet 59. An energy neutral process is thus achieved, because there is no needed exchange with the surroundings. This implies the advantage that condensation of the steam in an unwanted way is avoided at a step which has a lower temperature. If there were to be “cold steps” the process would stop, because the steam would condense in such a cold step instead of the wanted condensation in the downdraught evaporation heat exchanger 50.

When the polluted liquid is transferred into the processing vessel 41, which is connected to the scrubber 52, the shown level 60 for the processing liquid is achieved at a certain point of time, after which a float switch for regulation of the inlet of the polluted liquid 61 is activated, whereby a heating element (not shown) and a circulation

pump 43 are switched on. The temperature is hereby increased to a temperature and pressure, which is closely below the boiling point of the liquid, which is to be cleaned (the condensate). If the liquid is water the temperature is increased to approximately 100°C.

The circulation pump 43 is started up in the plant to ensure that all components have the same temperature. When the temperature has achieved about 100°C the compressor 49 is started. The compressur 49 creates a vacuum in the processing vessel 41 linked to the scrubber 52 and thereby forces the steam placed over the polluted and concentrated processing liquid 42 through the scrubber 42, after which the steam via the pipeline 48 is transferred to the heat exchanger 50, where heat exchange is taking place of the steam at the one side of the heat exchanger and the heated, polluted and concentrated processing liquid 42 on the second side of the heat exchanger. By this the steam, which has been compressed in the compressor 49, will loose its energy, which is transferred to the circulated polluted liquid 42 on the second side of the heat exchanger. This has the consequence of an evaporation of the liquid which is to be cleaned. This steam penetrates along the one side down to the downdraught evaporation heat exchanger 50 and is streaming down into the top of the process vessel 41, which is connected to the scrubber 52, and will thus pass via the steam outlet 47 and through the scrubber 52, the pipeline 48 and the compressor 49 into the heat exchanger 50. The steam is condensed during energy loss and can then be drained off as cleaned condensate via the outlet pipe 51.

Within the pipe from the compressor 49 to the downdraught evaporation heat exchanger 50 a scrubber 52 has been placed, which as mentioned above is separated into two parts. The upper part 54 contains a base (NaOH) and the lower part 53 an acid (HNO_3), which are supplied through a pipe for each liquid. This permits a regulation of the added amounts of acid and base, respectively, as a consequense of the results of the current measurements, so that the pH can be maintained constant during the entire evaporation. The upperstream part in the scrubber 52 (comprising the scrubber 53 and the scrubber 54) must always be supplied with acid in relation to the downstream alkaline part, because the acids are more mobile than the bases.

Both parts in the scrubber 52 are provided with devices for inhibition of bubbles, ripples and its like, which promotes splash and thereby risk of bringing droplets out into the steam pipe from the scrubber 52 to the heat exchanger 50.

The present approach, which is disclosed by this invention, is new and is remarkable in a surprising way which is advantageous in relation to the prior art and knowledge, including especially DK patent application 01288/96. The process according to the invention makes use of a mechanic and a process technical construction, which is more simple than the hitherto known technique within this field, which gives a lower level of expenditures. Apart from this the embodiment of this process renders advantages. It is thus a remarkable feature that the process is carried without supply and use of chemicals, which is a new and an obvious advantage with regard to the time period within which the process is taking place, as well as outside this time period. Concerning the time period in which the process is taking place, the hitherto known technology required thus a handling of the supply of the chemicals needed for the process. This handling is in all cases more or less laborious and therefore unwanted, which with the process according to the present invention can be avoided totally. Additionally, within that time period where the process is not working the needed chemicals to the process should - according to the hitherto known technique - be stored in a storage room, which of course is laborious and therefore desirable to avoid, and also the plant for both storage and handling should be approved by the authorities, which thus makes both the use and run of such a plant laborious. Those compounds, which are to be used here (see for instance DK patent application 01288/96), are favoured by a special attention by the authorities, because the use of the compounds are restricted environmentally, for what reason special measures are normally an inevitable requirement to an approval from the authorities. Finally it can be mentioned that the process according to the invention also has that economic advantage that the expenditures for purchase of chemicals are avoided, which makes the embodiment of the process cheaper in relation to the closest known technique.

The disadvantages by the known technology, which is here shown by an example of a plant, is thus clearly that the operation is connected with the relatively high consumption of energy and a high use of chemicals.

The present invention will in the following be detailed with basis in Fig. 3, which shows an example of a flowsheet for a plant, which uses this invention.

The apparatus, which is shown in Fig. 3, consists of a downdraught evaporation heat exchanger 50, through which the liquid, that is under evaporation and is to be cleaned, is circulated by means of the circulation pump 43, connected with the outlet from the processing vessel. The boiler liquid 42 is heat exchanging on its way down through the heat exchanger 50 with the condensing water steam from a absorption column 62, which constitutes an essential part of the present invention. Within the column 62 acid/base reactions are taking place as something very essential for the invention. Said acid/base reactions are taking place between the present weak acids and weak bases, which as mentioned are more mobile compounds and less mobile compounds as judged relatively to the mobility of water. By the heat exchanging 50 the liquid is brought to the boiling point.

The downdraught evaporation heat exchanger 50 is placed above the boiler 42 in which a reservoir of liquid being under evaporation is present. The liquid is circulated by means of the pump 43. The pressure in the boiler 42 is kept constant during the evaporation by means of a pressor state 63 (for regulation of the heating element 64) which is activated when the pressure is below 5 mmbar overpressure compared to the surroundings. The steam which arises by the boiling of the liquid in the heat exchanger 50 is streaming together with the liquid down into the boiler 42.

In the boiler 42 a liquid/steam separator 65 is placed which separates liquid and steam from each other, whereby the liquid is kept within the boiler 42, which the steam leaves through the separator 65. The steam flows from the liquid/steam separator 65 to the absorption column 62, in which the main part of impurities in the steam is removed. From the absorption column 62 the steam is flowing to the compressor 49,

which gives the steam an increase pressure, whereby the condensation temperature of the steam increases to such a degree that the steam is able to condense, when it flows over to the heat exchanger 50.

The condensate from the steam runs down to the bottom of the heat exchanger 50, in which it is collected until a certain level is achieved, which is determined by the float switch 66, which by activation opens valve 67 which permits the condensate to flow to the vessel 68. The level of liquid in boiler 42 is kept constant by means of valve 70, which opens by activation through the float switch 69 which permits that the liquid which is to evaporate flows through said valve 70, a first heat exchanger 71 (in which the polluted liquid heat exchanges with the condensate), a second preheat exchanger 72 (in which the polluted liquid is heat exchanging with the steam) and is mixed with the liquid from the boiler 42, which is under evaporation and thereafter introduced into the downdraught evaporation heat exchanger 50.

In the condensate vessel 68 a reservoir of condensate is collected until the level which is determined by the level sensor 73 is achieved, which permits that the valve 74 opens and 75-95% of the condensate (abbreviated C_d) leaves the apparatus through the first preheat exchanger 71, which is the heat exchanger which receives the incoming aqueous liquid W.

A part of the condensate (5%-25%) is pumped by means of pump 75 to the top of the absorption column 62, in which it is distributed to the column elements within the column. On its way down to the absorption column 62 the condensate absorbs the impurities from the steam, which rises up from the boiler 42 and acid/base reactions are taking place. In the legend to Fig. 4 these reactions are further explained.

The condensate containing the impurities is led from the bottom of the absorption column 62 to the process vessel 41, which is connected to the scrubber 52, in which it is mixed with the liquid which is under evaporation and cleaning. The part of the steam containing the more mobile compounds is led from the column 62 via the compressor 49 to the heat exchanger 50. The part hereof, which by passing through the heat ex-

changer 50, is not condensing, will in concentrated form together with the remaining amount of steam, flow over into the second preheat exchanger 72, in which it is cooled and condensed by heat exchanging with the incoming liquid W, to which is hereby added a further temperature rise. When the gas/liquid mixture temperature in the second heat exchanger 72 has fallen down to a certain level the termostate 76 is activated, whereby valve 77 opens, and the gas/liquid mixture flows to the vessel 78, in which the gas phase is separated from the liquid phase in the gas/liquid mixture in the second preheat exchanger 72.

The gas is drained off and in vessel 78 a reservoir of liquid is built up until a certain level determined by level sensor 79, after which valve 80 opens and the liquid flows to the process vessel 41, in which it is mixed with the liquid under evaporation and cleaning.

Fig. 4 shows that part of the plant in Fig. 3 that in concentrated form visualizes the invention, which thus combines an absorption column with a heat exchanger in which the condensate runs in counterstream with the steam which is to be condensated with an evaporation system.

Fig. 5 shows an example of an absorption column according to the invention, where a part of the condensate flows in countercurrent with the steam flowing from below. In the column the surface of the column elements is giving place for a number of acid/base reactions. Some relevant reactions in this connection are the equilibrium reaction (1)-(4)

(1) CH_3COOH (gas) <----> CH_3COOH (aq),

(2) CH_3COOH (aq) <----> $CH_3COO^- + H^+$,

(3) NH_3 (gas) <-----> NH_3 (aq),

(4) NH_3 (aq) <-----> $NH_4^+ + OH^-$,

which in addition are shown in the circle of the figure. In the left side of the circle are shown the compounds from the below coming steam and what is mentioned in the right side are relevant equilibria for what is flowing down to the bottom vessel.

Fig. 6 shows a heat exchanger according to the invention. On the figure is shown a downdraught evaporation heat exchanger, in which the condensing steam flows countercurrent to its own condensate.

The more mobile compounds in the steam, compared to the mobility of water, will be collected and drained off from the top of the heat exchanger. If the waste liquid which is to be cleaned is manure then a ammonia will be a big part of the above mentioned drained off material. At the bottom the condensate which is the cleaned liquid will be drained off.

Explanation for designations in Figs. 1-6:

1: column
2: first heat exchanger
3: compressor
4: bottom vessel for the column 1
5: circulation pump receiving liquid from outlet 36
6: motor valve
7: contra valve
8: gas/liquid separator
9: level sensor
10: first section of heat exchanger
11: second secton of heat exchanger
12: third heat exchanger
13: first motor valve
14: second motor valve
15: nozzles for draining off of liquid biological waste from column 1
16: inlet for liquid biological waste to column 1

17: foam restrictor for upper part of column 1

18: inlet for manure

19: outlet from first section 10 of second heat exchanger

20: inlet for second section 11 of second heat exchanger

21: outlet from second section 11 of second heat exchanger

22: outlet from foam inhibitor 17

23: inlet for the primary side of the first heat exchanger 2

24: outlet from the primary side of the first heat exchanger 2

25: inlet from the primary side of the second section 11 of the second heat exchanger

26: outlet from second section 11 of second heat exchanger

27: inlet to gas/liquid separator 8

28: outlet from separator 8

29: inlet containing liquid for the nozzles 30

30: nozzles 30 in column 1

31: outlet containing gas fraction from the separator 8

32: inlet containing the gas fraction to the primary side of the third heat exchanger

33: outlet from primary side of the third heat exchanger

34: inlet containing manure to the secondary side of the third heat exchanger 12

35: outlet from the secondary side of the third heat exchanger 12

36: outlet from the bottom vessel 4

37: inlet from the secondary side of the first heat exchanger 2

38: outlet from the secondary side of the first heat exchanger 2

39: evaporator

40: a liquid distribution system

41: process vessel connected with scrubber 52

42: concentrated process liquid (concentrate Cc)

43: circulation pump connected with the outlet from the process vessel

44: circulation pipe

45: inlet pipe

46: outlet pipe with outlet of concentrate (Cc)

47: steam tapping

48: pipe for steam

49: compressor

50: downdraught evaporation heat exchanger

51: outlet pipe for clean condensate

52: scrubber comprising scrubber 53 and 54

53: scrubber containing acid

54: scrubber containing base

55: acid

56: base

57: pipe for acid

58: pipe for base

59: isolated cabinet

60: level hight for process liquid

61: level sensor for regulation of supply of polluted liquid

62: absorption column

63: pressostate for regulation of heating element 64

64: heating element

65: separator for separation of steam and liquid

66: float switch, which by activation opens valve 67

67: valve, which by opening permits condensate to flow to vessel 68

68: vessel for condensate

69: float switch, which by activation opens valve 70

70: valve, which by opening permits the polluted liquid to pass through to a first preheat exchanger 71

71: first preheat exchanger, through which the polluted liquid heat exchanges with condensate

72: second heat exchanger, in which the polluted liquid heat exchanges with steam

73: level sensor (in vessel 68), which by activation opens valve 74

74: valve which by opening permits the condensate (Cd) to pass through the first preheat exchanger 71

75: pump, which takes a part of the condensate to the top of 62

76: termostate which by activation opens valve 77

77: valve which opening permits the gas/liquid mixture from 72 to pass further on to vessel 78

78: vessel, in which gas phase is separated from liquid phase in the gas/liquid mixture in 72

79: level sensor, which by activation opens valve 80

80: valve which by opening permits the liquid to flow further to the process vessel 41

C_c: See 42 and 46 above

C_d: See 74 above

W: Incoming polluted liquid, which is desired to be cleaned.

CLAIMS

1. Process for cleaning of biological waste water which contains more mobile compounds and less more compounds compared to the mobility of water, said compounds being present as weak acids and weak bases, by evaporation of the waste water, by heating the waste water in a boiler, where the generated steam is cleaned for unwanted gaseous compounds, where the steam is taken from the boiling step via a compression step to a heat exchanging step, where the water is condensed, c h a r a c t e r i z e d in that the steam from the boiler is conducted to a column, in which the steam is flowing countercurrently to a fraction of the condensed water in order to in a liquid form to remove the less mobile compounds including a part of the more mobile compounds and the less mobile compounds which are taken part in the acid/base reactions, in that the steam fraction containing a remaining part of the more mobile compounds are led from the column via the compression step to the heat exchanging step, where the main part of the more mobile compounds are concentrated and drained off together with a remaining fraction of the steam, and in that the condensed and cleaned waste water is drained off to recipient.

2. Process according to claim 1, c h a r a c t e r i z e d in that the waste water is manure, which contains compounds, which comprise CO_2, NH_3, NH_4^+, fatty acids including CH_3COOH, where the less mobile compounds and the more mobile compounds are able to take part in acid/base reactions, and in that a part of the condensate from the heat exchanger is led countercurrently to the steam, which is conducted to the column from the boiler

3. Process according to claim 1 or 2, c h a r a c t e r i z e d in that the steam which has left the column is condensed in a heat exchanger with its own condensate as countercurrent flow.

4. Process according to any of the preceding claims, c h a r a c t e r i z e d in that acid/base reactions in the column are taking place upon the surface of the column elements.

5. Process according to any of the preceding claims, c h a r a c t e r i z e d in that the remaining fraction of the condensed water which is led to the column constitutes 5-25% of the total condensate.

6. Process according to any of the preceding claims, c h a r a c t e r i z e d in that the compounds which in liquid form are led from the column and back to the boiler are emptied herefrom when the concentration has achieved a predetermined level.

7. Process according to any of the preceding claims, c h a r a c t e r i z e d in that the heat exchanging step is carried out in a downdraught evaporation heat exchanger, where the gas fraction flows countercurrently with its own condensate.

8. Apparatus for use in the process according to any of the preceding claims and which comprises a boiler, a column, a compressor, and a heat exchanger, where the compressor is placed between the column and heat exchanger, and where a pump is placed between the boiler and heat exchanger for tranference of the content of the boiler to the heat exchanger for heat exchanging of the steam from the column and c h a r a c t e r i z e d in that the column is connected with a steam tapping from the boiler.

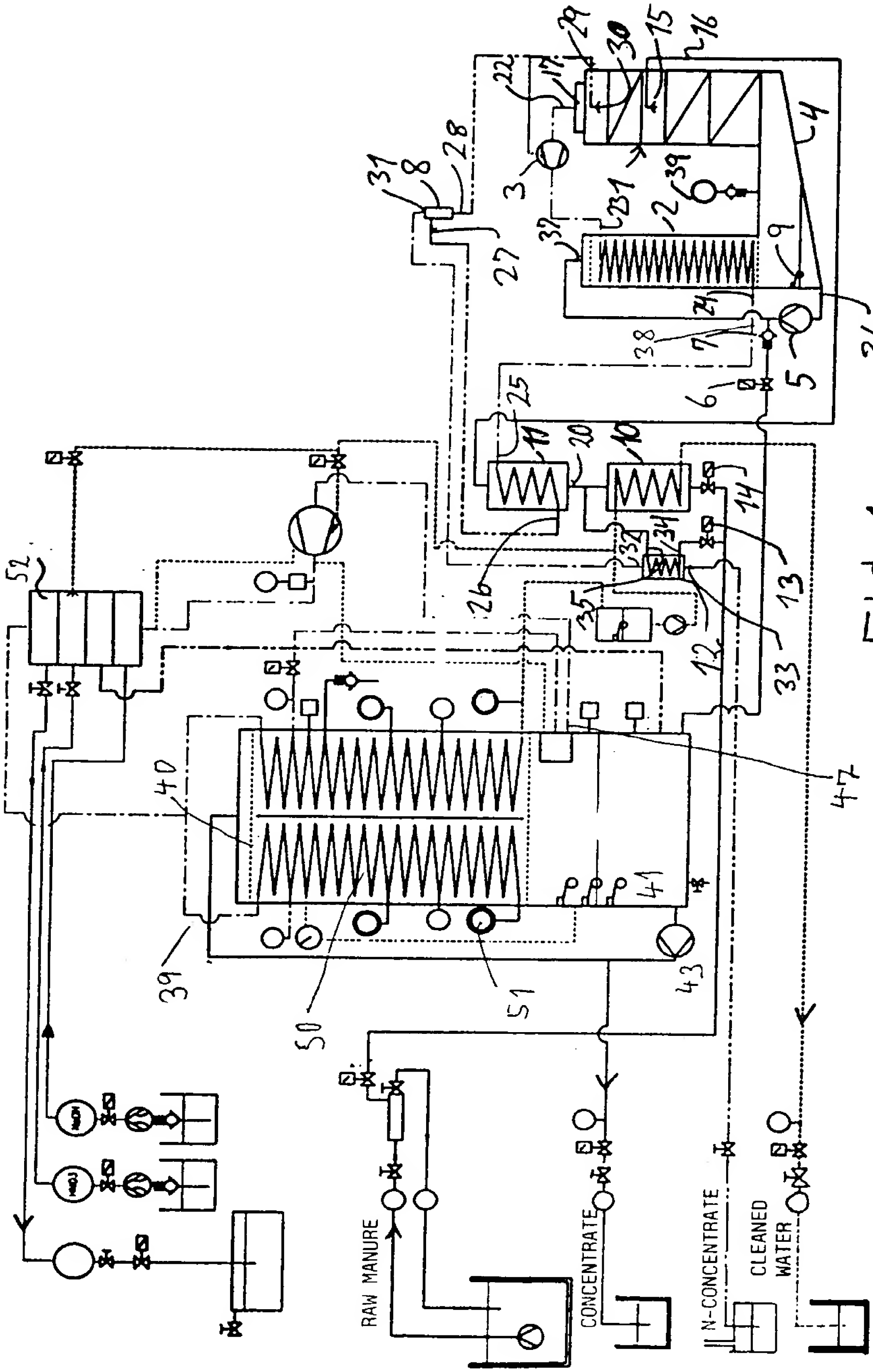

FIG. 1

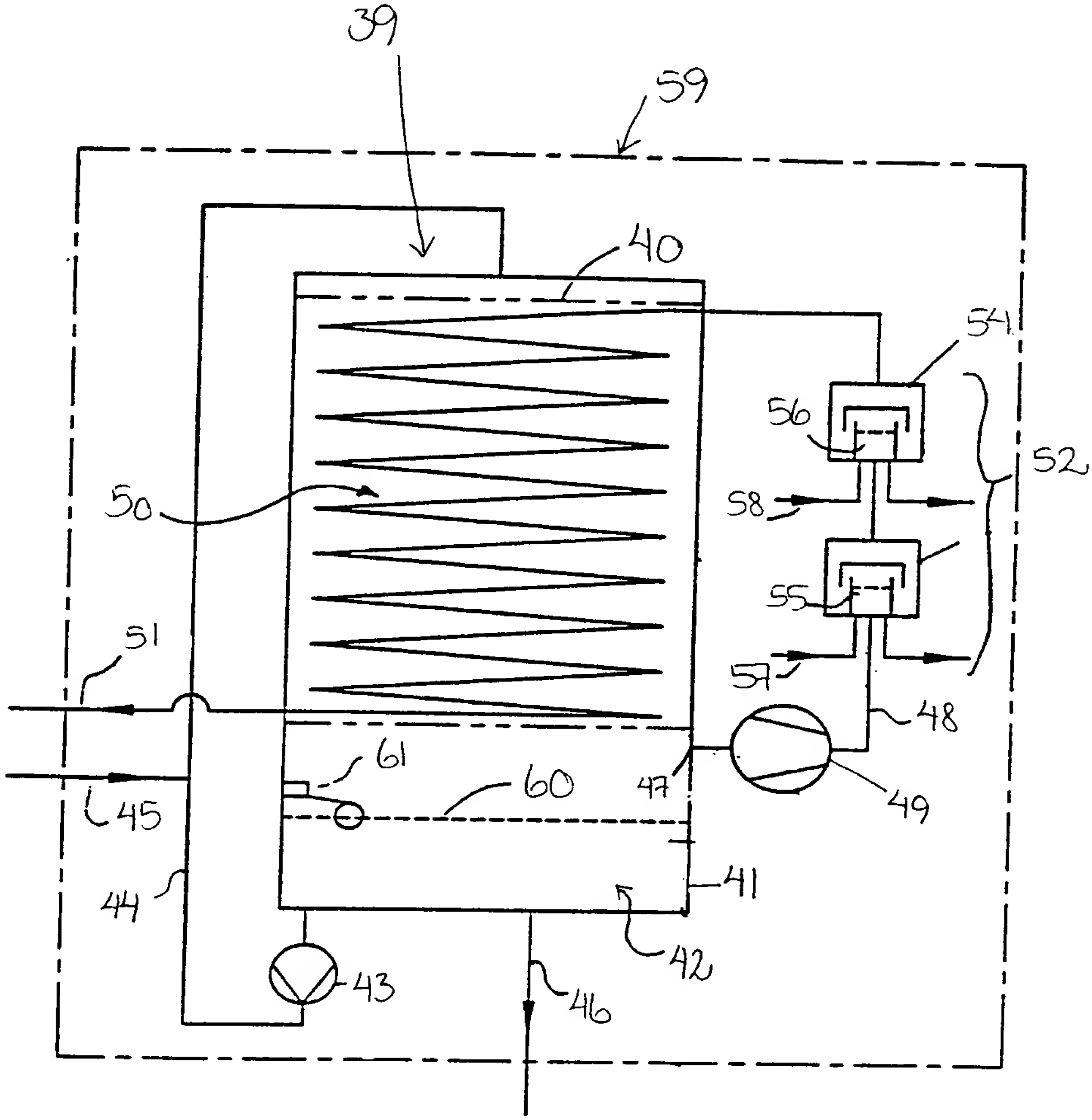

Fig. 2

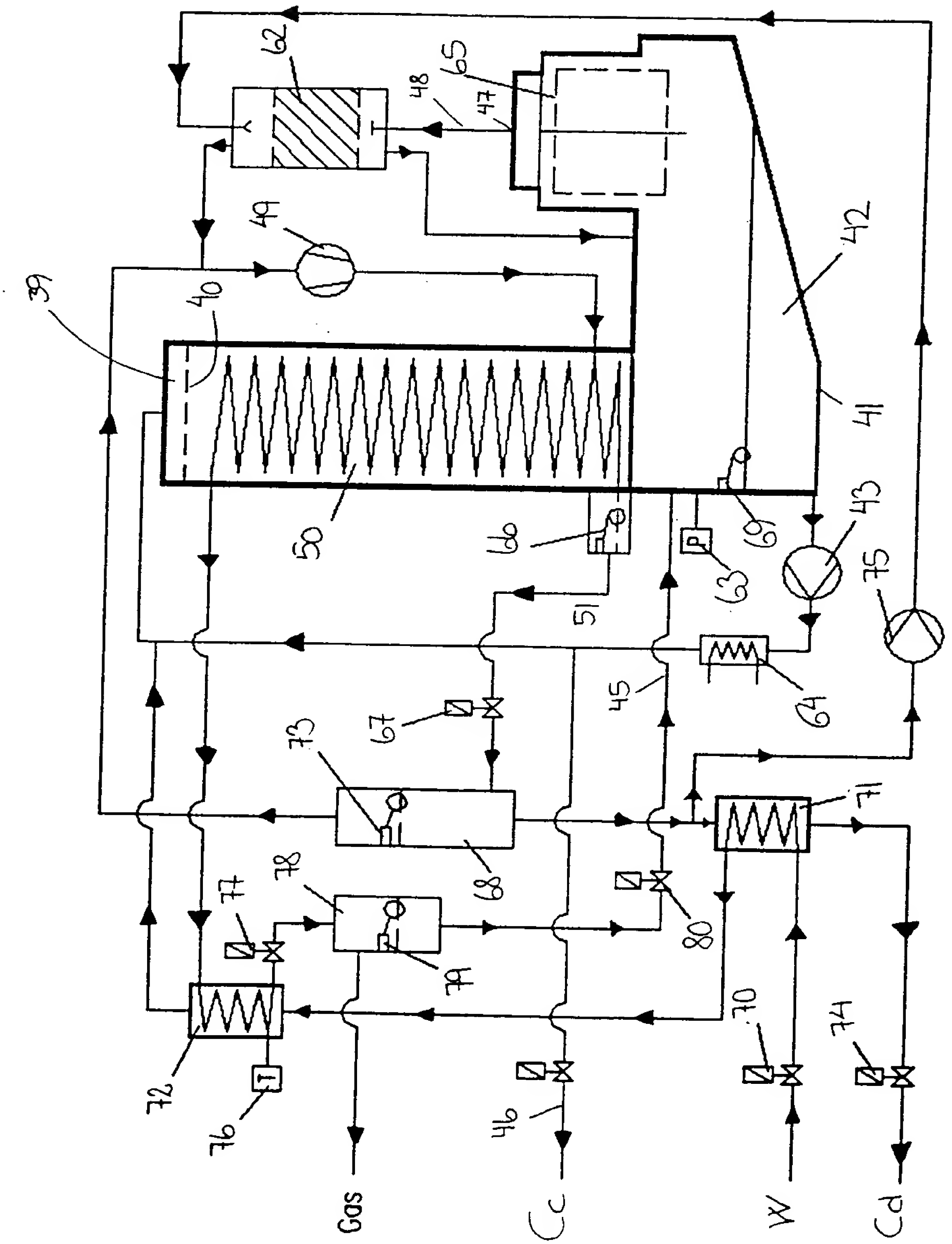

Fig. 3

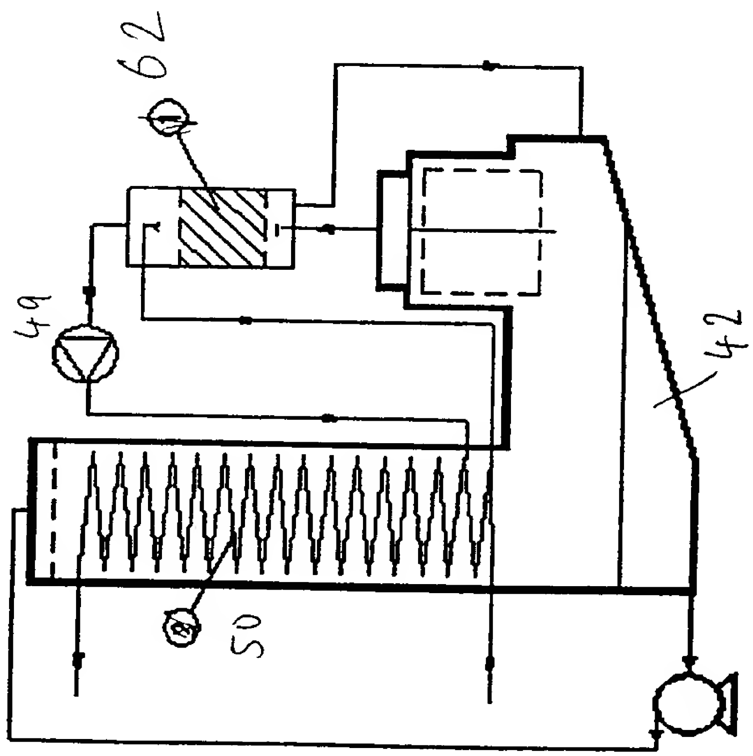

Fig. 4

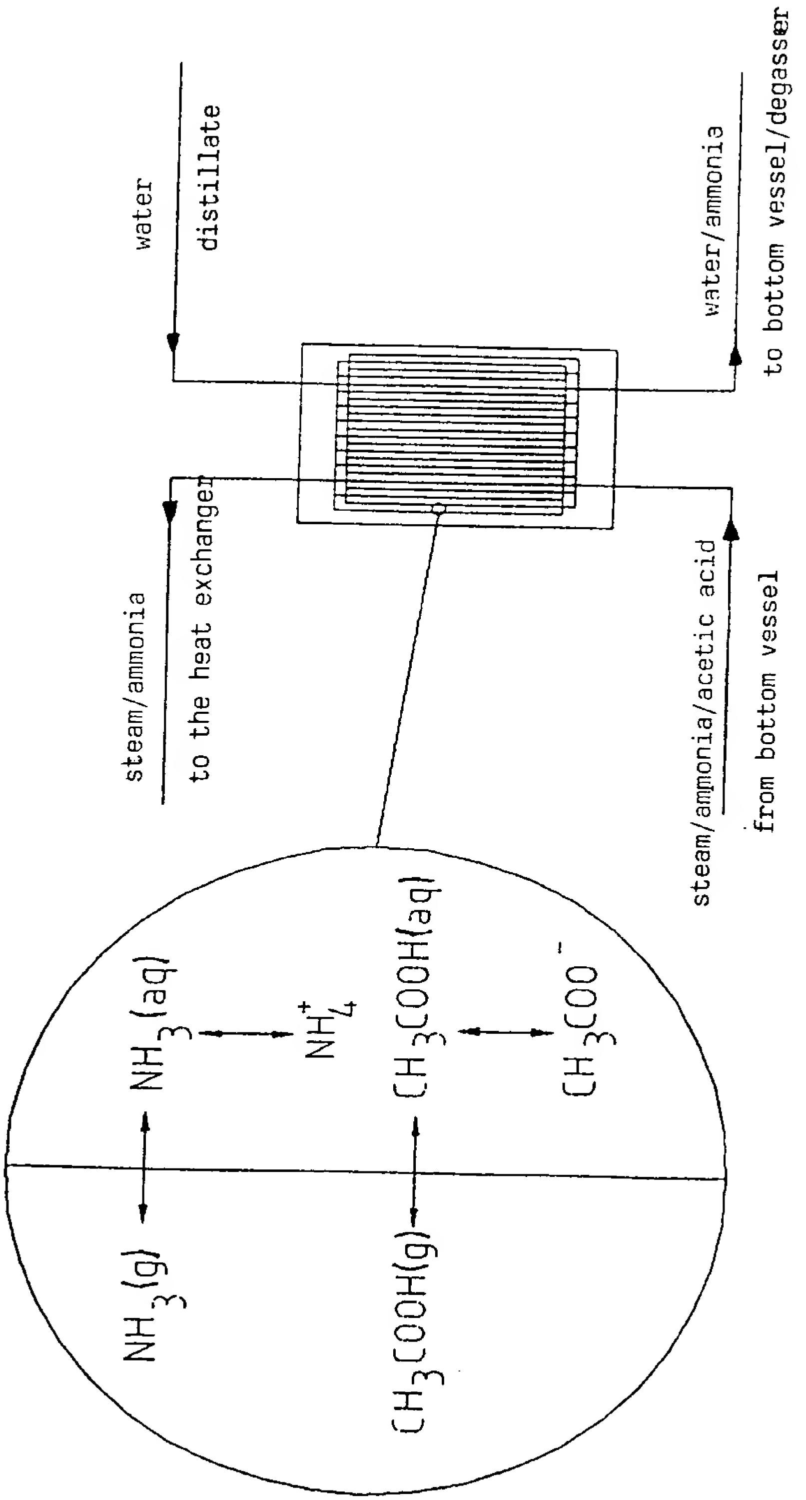
water
distillate
water/ammonia
to bottom vessel/degasser
steam/ammonia
to the heat exchanger
steam/ammonia/acetic acid
from bottom vessel
$NH_3(g)$
$NH_3(aq)$
NH_4^+
$CH_3COOH(g)$
$CH_3COOH(aq)$
CH_3COO^-

Fig. 5

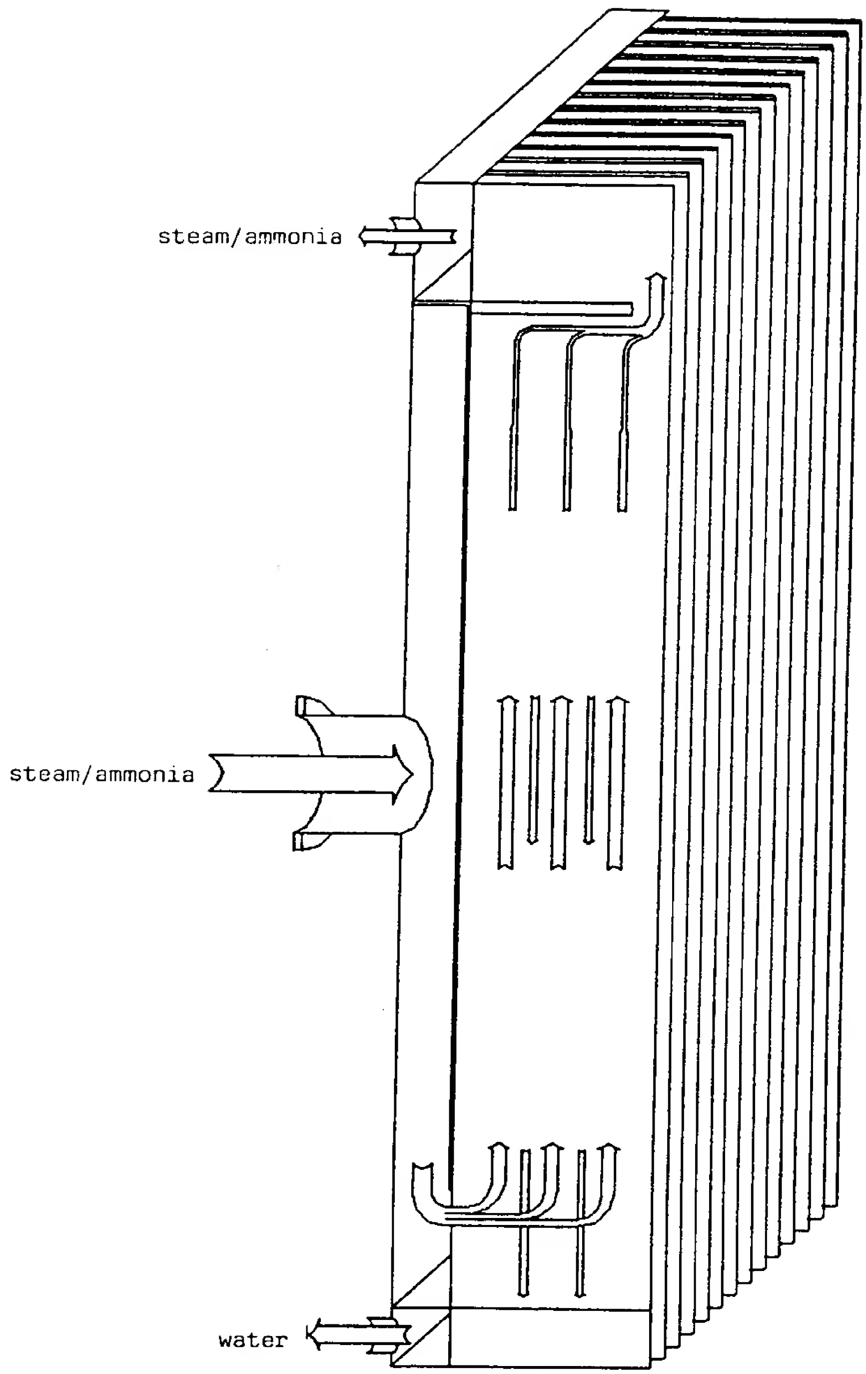

Fig. 6